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System Operator

Role of Energy Storage in California ISO Grid Operations

Presented by

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at

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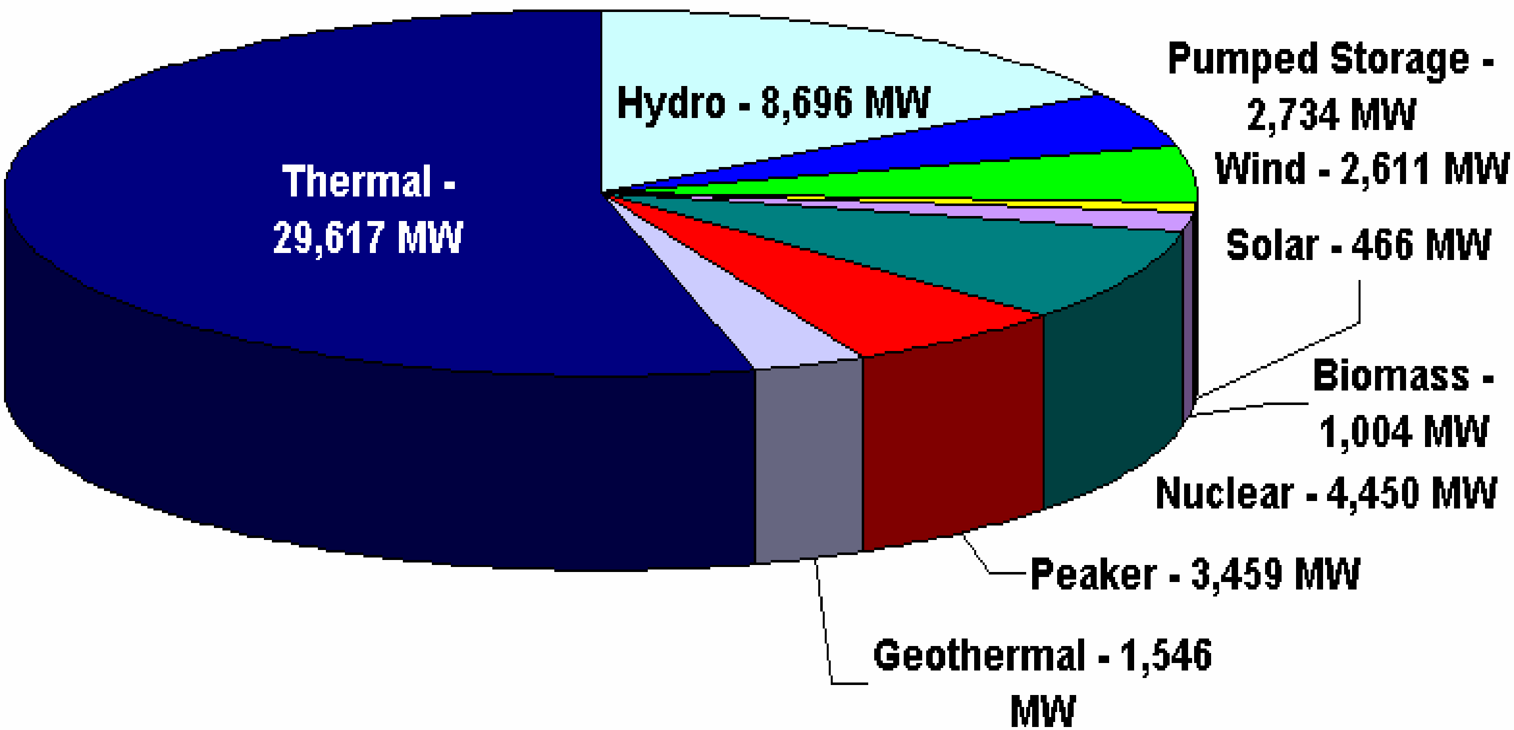
CAISO Control Area Generation by Technology

(As of April 1, 2004 before de-rates for availability)



Value of Hydro Generation

A Control Area Operator's Perspective

- Fast response to control signals, frequency problems, and automated dispatch commands
- High ramp rates
- High reliability and stability
- Easy to start and stop
- Lower cost energy but limited in supply
- Units are frequent suppliers of Regulation Services
- Pump storage facilities have added advantage of providing night time loads to help balance system

Helms Pump Storage Plant

- 3 – 300 MW units capable of both generation and pumping.
- Typical time to turn around units between pumping mode and generation mode is 5 minutes.
- Units are bid into the market like any other units with cost curves for increasing and decreasing generation
- When units are in pumping mode, they are typically flat loaded at –309 MWs. Often only 1 or 2 units are on at a time but all 3 can be run if Path 15 is not heavily loaded S to N and Fresno Generation is on
- Plant owner is responsible for managing the level of water in the pond and for scheduling the plant

Helms in Pumping Mode

- Must be bid into the market and scheduled
- Typical pattern is to bring on pumps at night when the other loads are dropping off the system
- Very useful for balancing the resource portfolio of having enough night time load to provide room for Diablo Canyon power plant output and other plants that need to stay on at minimum loads.
- Units must stay on for an hour minimum when dispatched.

Economic Incentives for Energy Storage

- Need price differential between off-peak and on-peak periods for incentive to store energy
- Pump storage plants typically have a 70% efficiency rating so for every 100 MW Hrs of pumping energy consumed, the plant can return 70 MW-Hrs of energy to the system
- In 2002, pump storage plants used 1,930,639 MW-Hrs of energy for pumping
  - Net energy to serve load in 2002 was 224,121,165 MW-Hrs

On-Peak versus Off-Peak prices for November 2004

Table 2. Average Real-Time Prices, Net Real-Time Energy, Average Loads, and Underscheduling, for November

	In-Seq. RT Dispatch	OOS/OOM Dispatch	Total Dispatch	Average Loads and % Underscheduling
PEAK	$ 62.59 /MWh (67.4) GWh	$ 45.16 /MWh (115.5) GWh	$ 56.66 /MWh (182.9) GWh	27,830 MW 0.3%
OFFPEAK	$ 43.14 /MWh (14.6) GWh	$ 18.11 /MWh (80.2) GWh	$ 35.35 /MWh (94.8) GWh	22,130 MW 1.3%
ALL	$ 56.24 /MWh (82.0) GWh	$ 37.09 /MWh (195.7) GWh	$ 49.91 /MWh (277.7) GWh	25,423 MW 0.7%

Prices are based on the new Real Time Market Economic Dispatch system that was implemented in October 2004. This system does a 5 minute economic redispatch of system resources to match system load

On-Peak versus Off-Peak prices for December 2004

Table 3. Average Real-Time Prices, Net Real-Time Energy, Average Loads, and Underscheduling, for December

	In-Seq. RT Dispatch	OOS/OOM Dispatch	Total Dispatch	Average Loads and % Underscheduling
PEAK	$ 55.71 /MWh (118.8) GWh	$ 46.05 /MWh (141.4) GWh	$ 52.37 /MWh (260.2) GWh	29,140 MW -0.8%
OFFPEAK	$ 46.41 /MWh (14.7) GWh	$ 34.07 /MWh (89.6) GWh	$ 42.58 /MWh (104.3) GWh	23,396 MW 1.0%
ALL	$ 52.56 /MWh (133.6) GWh	$ 42.41 /MWh (231.0) GWh	$ 49.17 /MWh (364.6) GWh	26,731 MW 0.0%

Prices are based on the new Real Time Market Economic Dispatch system that was implemented in October 2004. This system does a 5 minute economic redispatch of system resources to match system load.

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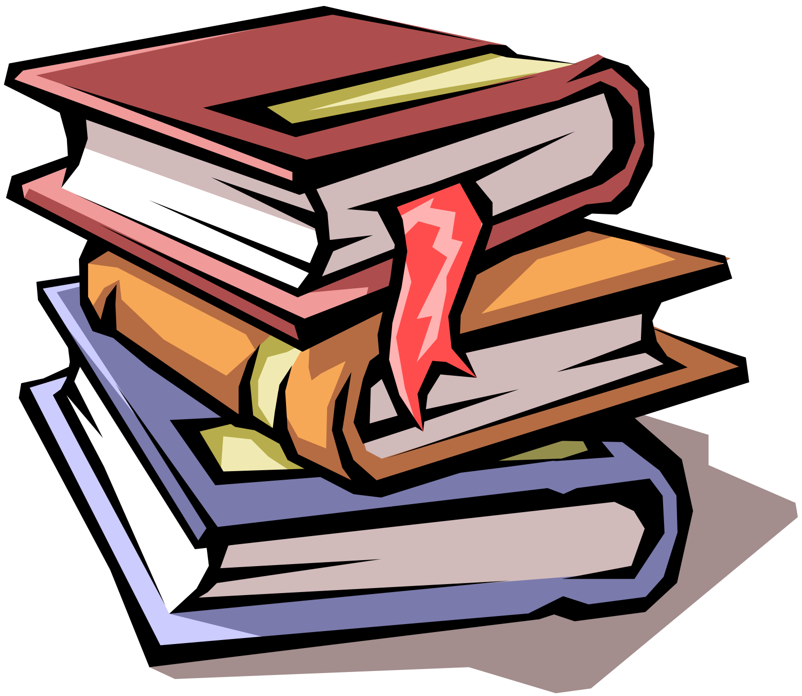
Methodologies for Analyzing Cost – Benefits of Energy Storage Technology

- EPRI-DOE Handbook of Energy Storage for Transmission and Distribution Applications
- EPRI-DOE Handbook Supplement for Energy Storage for Grid Connected Wind Generation Applications



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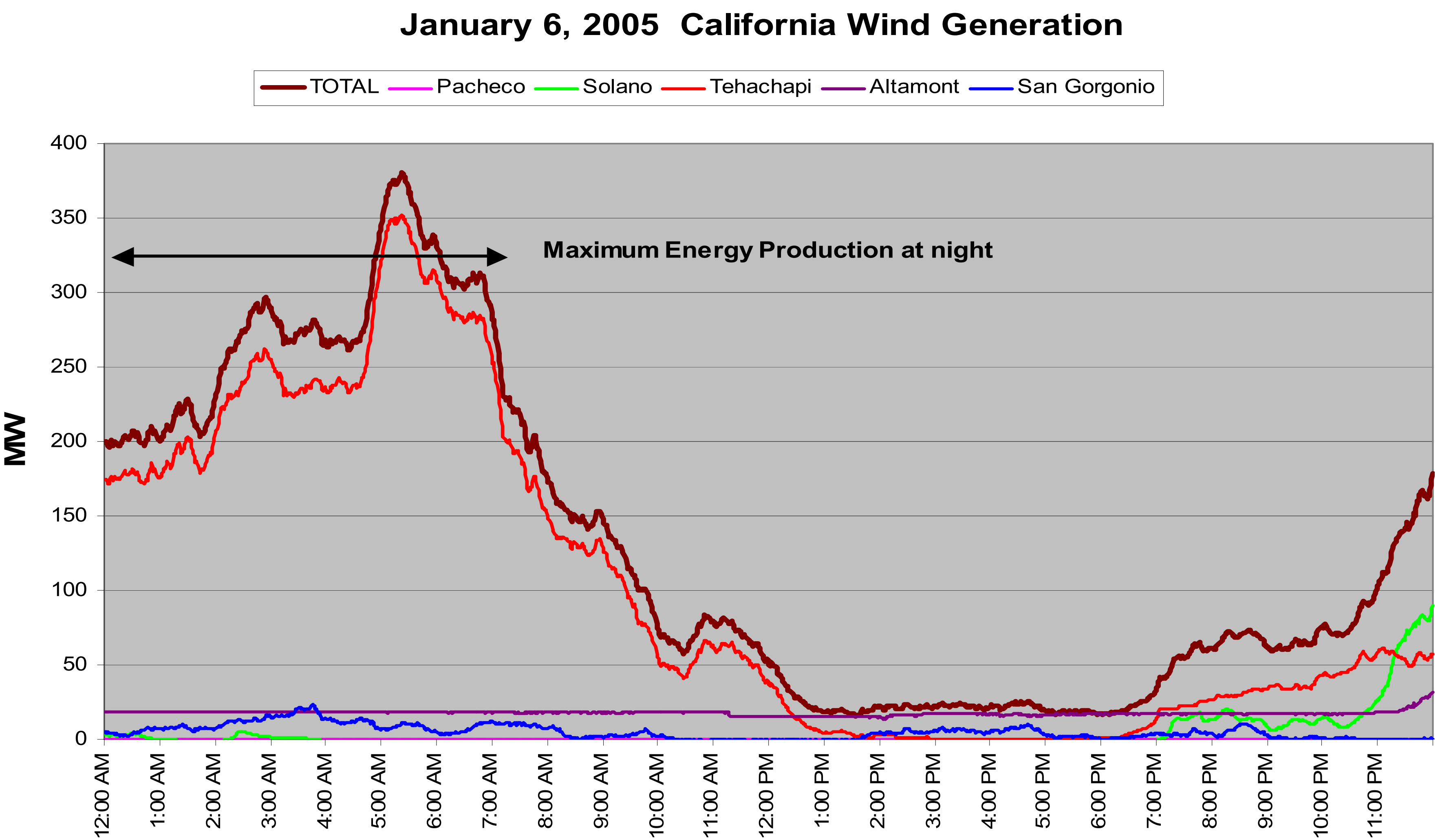
Need to Shift Some Wind Energy Production from Off-Peak to On-Peak



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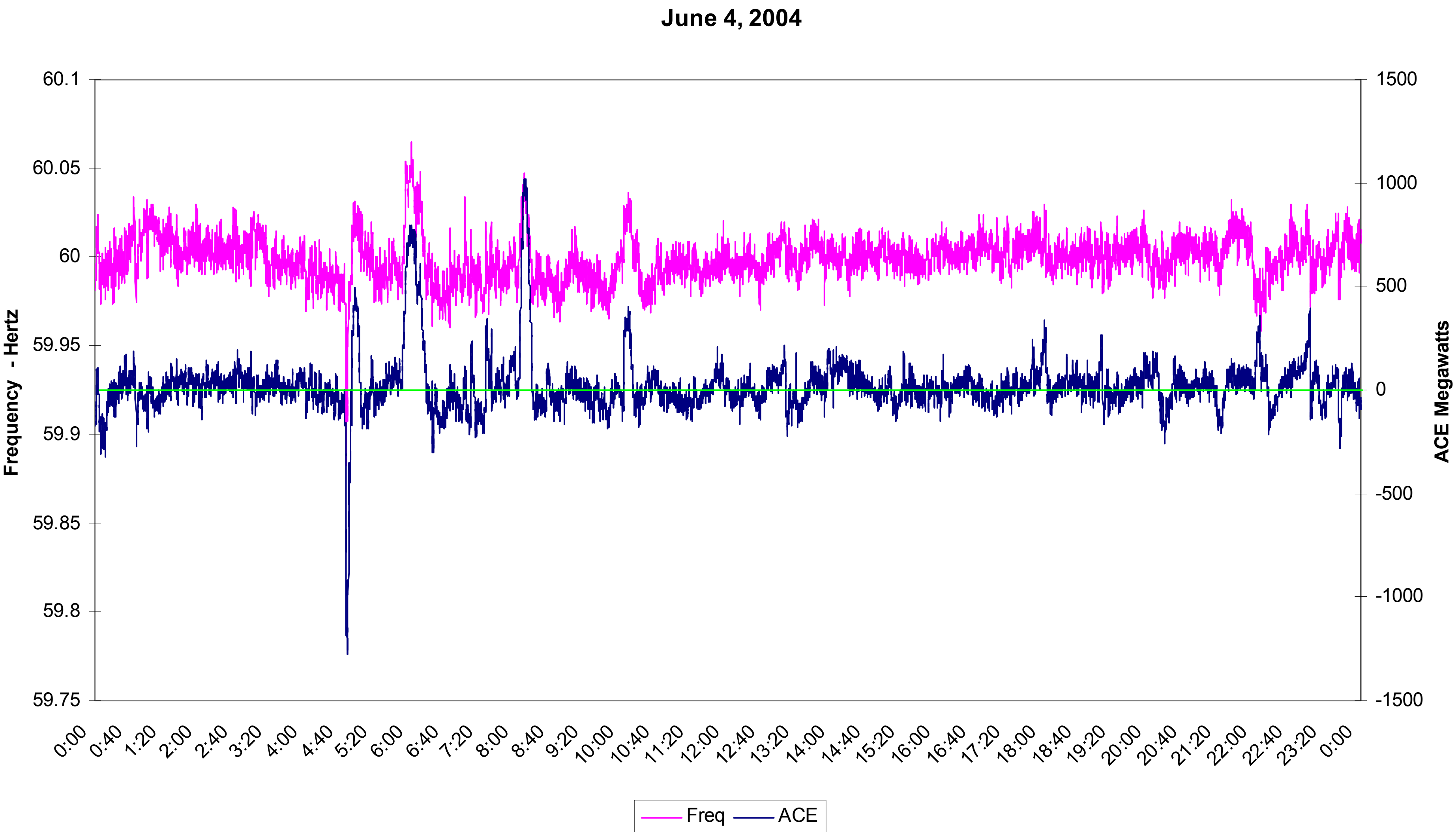
Potential use of Flywheel Energy Storage for ACE and Frequency Control



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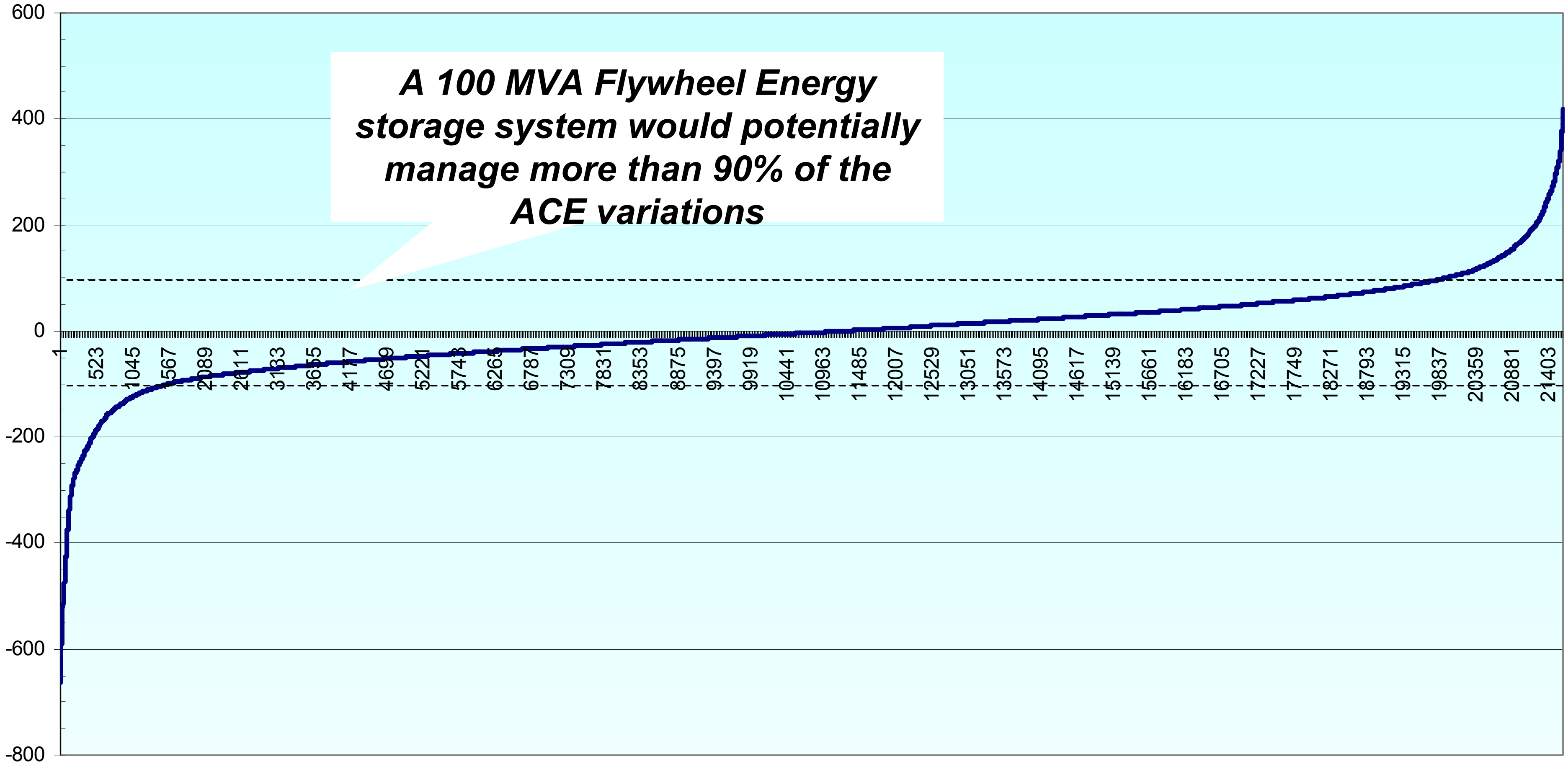
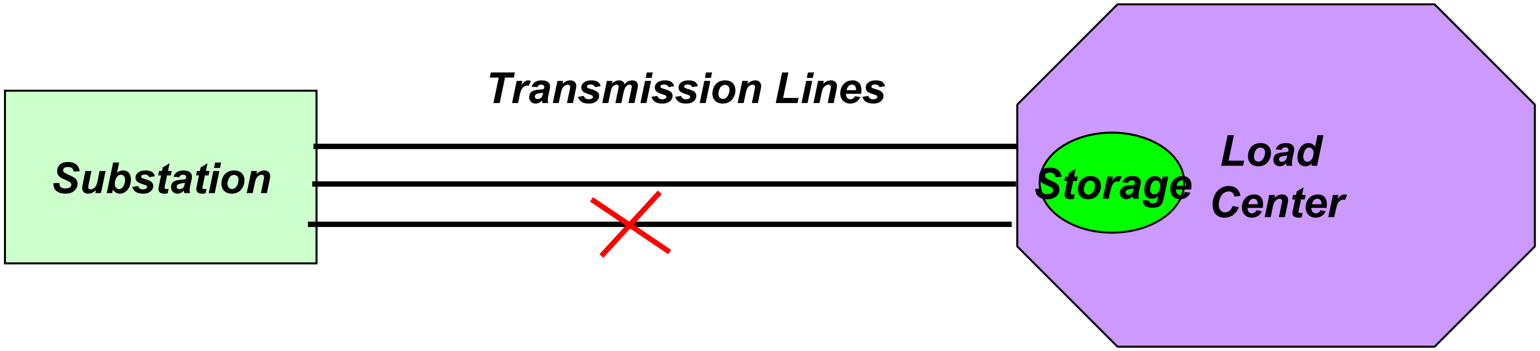
Potential use of Flywheel Energy Storage for ACE and Frequency Control

Variation of 4 Second ACE over a 24 hour Period



Other uses of Energy Storage



In the event a transmission line is lost, the storage system could inject energy into the load center area to temporarily help unload the overloaded lines. It could also provide voltage support and potentially reduce the need for some RMR contracts.

Action Needed

- Energy Storage technology is rapidly developing and the costs are coming down
- We need to do more work on development of the economic models and quantification of the benefits that could be achieved with storage systems
- Field tests of this technology should be funded
- The portfolio of new and existing generation resources such as Combined Cycle Combustion Turbines and Intermittent Resources demand that we invest in new technologies to help control frequency and the rate of recovery from loss of generation